

## Market Factors and Government Programs Affecting U.S. Corn Prices

by

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**Abstract:** An annual model for the U.S. farm price for corn is based on market factors as well as Governmental price support programs in selected years. The U.S. price support program affected corn prices, particularly in the late 1970s through the mid-1980s. Changes in the price support program since 1986 have resulted in less interference of that program with price determination. The model presented includes a shift variable to account for years when the corn price support program affected market prices. With the declining role of Government commodity programs in agriculture, price determination for corn now is based on market supply and demand factors. The stocks-to-use ratio provides a summary measure of supply and demand and is a useful indicator of corn price movements. Model estimates for 1997/98 corn prices are compared with USDA projections. Implications of U.S. agricultural policy changes for potential inter-year, annual corn price variability are discussed.

**Keywords:** Corn, farm price, price determination, stocks-to-use ratio, price supports, commodity programs, forecasts.

The U.S. corn crop plays a major role in the agricultural sector. As a source of income to farmers, corn cash receipts are the largest among crops. Over the last 5 years, corn cash receipts have averaged more than \$17 billion, accounting for nearly 18 percent of total crop cash receipts. Corn also has an important role in linkages within the agricultural sector among various crops and between crops and livestock. Corn competes with other crops for land in farmers' production decisions, particularly soybeans. Corn is also the largest feed grain used by the livestock sector. Further, the United States is the largest exporter of corn, accounting for over 70 percent of global corn trade thus far in the 1990s. Consequently, events which affect the corn sector and corn prices are carefully watched by many subsectors within agriculture.

Agricultural legislation enacted in 1996 fundamentally changed the nature of farm commodity programs in the United States, furthering trends toward market orientation in the sector. In particular, changes in the income support program shifted much of the risk of price volatility from the Government to producers (see Young and Westcott). As a result, market information affecting corn prices is particularly important under the 1996 Farm Act as farmers seek to make informed farm management decisions to manage risk and other market participants work within a more market-oriented agricultural sector.

To provide market information regarding the agricultural sector, each month the U.S. Department of Agriculture (USDA) analyzes major agricultural commodity markets and publishes annual supply, demand, and price projections for the current year. Additionally, once a year USDA publishes longer term, 10-year baseline projections for the agricultural sector that include commodity supply, demand, and prices.

This paper examines some of the factors that affect farm-level U.S. corn prices. An annual framework is employed to develop a corn price model designed to be used in USDA's projections activities in conjunction with ongoing commodity market analysis of supply and demand factors. The model builds on two types of factors that influence prices—market supply and demand conditions, and Government price support programs.

Market forces, as measured by supply and demand, influence prices. Year-ending stocks of an annually produced commodity, such as corn, summarize the effects of both supply and demand factors during the year, and are a useful indicator of price movements for the commodity. Annual prices for corn tend to have a strong negative correlation with their ending stocks. High corn stocks typically result in lower prices, while low stocks tend to push prices up.

Historically, Government programs have also been important in influencing farm-level corn prices. Some programs, such as acreage reduction and set aside programs, have

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influenced prices indirectly by placing restrictions on the use of land for agricultural production, thereby affecting the supply of agricultural commodities. The nonrecourse commodity loan program has directly affected prices by providing support to farm-level prices and affecting market equilibrium in some periods. The key policy variable used in the price modeling effort in this article is the price support loan rate. However, the role of the loan rate in influencing prices has differed historically as the nature of the commodity loan program has changed under different farm legislation.

### Previous Research

Many corn price models have employed the stocks-to-use ratio to represent market conditions in explaining movements in corn prices. The stocks-to-use ratio is defined as stocks of the commodity at the end of a particular time period divided by use of the commodity during that time period. As such, market conditions of supply and demand are summarized in this measure. Van Meir, and Baker and Menzie used stocks-to-use ratios in annual frameworks analyzing corn prices, while Westcott, Hull, and Green used such an approach in a quarterly model for corn prices. Numerous other unpublished annual corn price models using stocks-to-use ratios have been used internally within USDA in its forecasting activities. In each model, the stocks-to-use variable is negatively related to corn prices and provides a downward sloping, nonlinear curve of prices plotted against ending stocks-to-use.

To represent the effects of Governmental price support programs on prices, many corn price models have been estimated with the dependent variable of price minus loan rate. The Baker and Menzie annual corn price model and part of the Van Meir analysis of corn prices and stocks used this approach, as did most of the unpublished USDA models. The U.S. price support program affected corn prices, particularly in the late 1970s through the mid-1980s. During this period, the support program's loan rate for corn was generally high enough to influence market prices. However, changes in the price support program since 1986 have resulted in less interference of that program with price determination.

### Price Support and Commodity Storage Programs for Corn

The commodity price support program for corn allows producers to receive a loan from the Government at a designated loan rate per unit of production by pledging some of their corn production as loan collateral. Following harvest of the corn crop, a farmer who has enrolled in the corn program may obtain a loan for some portion of the new crop. For each bushel put under loan and pledged as loan collateral, the farmer receives a per-bushel amount equal to that year's loan rate. Under the loan program, the producer must keep the crop designated as loan collateral in approved storage to

preserve the crop's quality. The producer may repay the loan at any time during the length of the loan, usually 9 months, paying back the loan principal plus accrued interest charges. However, at the end of the 9-month loan period, the farmer may choose instead to default on the loan rather than repay it, keeping the loan money and forfeiting ownership of the loan collateral (the corn) to the Government. Defaulting on the loan would make economic sense for the producer if the market prices were below the loan rate (plus interest), because the producer would effectively have received the loan rate for the crop rather than the lower market price.

Historically, loan rates were set high relative to market prices in the late 1970s through the mid-1980s (figure E-1). Loan program defaults resulted in the acquisition of corn by the Government, and Government stocks of corn reached over 1.1 billion bushels in 1982, or 15 percent of annual use (figure E-2). Also, a multi-year Farmer-Owned Reserve (FOR) program was begun in the late 1970s, which provided storage subsidies to farmers to store grain under loan for 3 to 5 years. Additional price support was provided under the FOR program in 1980-1982, with a higher reserve loan rate than available under the regular, 9-month loan program. The long duration of the FOR program, combined with high release prices needed for grain to exit the reserve, effectively isolated a large amount of grain from the marketplace. By 1982, corn held in the FOR rose to almost 1.9 billion bushels, about 26 percent of annual use. The combination of high price supports along with stocks being isolated from the marketplace in the FOR resulted in a significant policy effect on corn prices.

Changes in the price support program since 1986 have resulted in less interference of that program with price determination. Three important policy features of farm programs under legislation enacted in 1985 significantly changed the loan program and the effect of price supports

Figure E-1  
**Corn Price and Loan Rate**

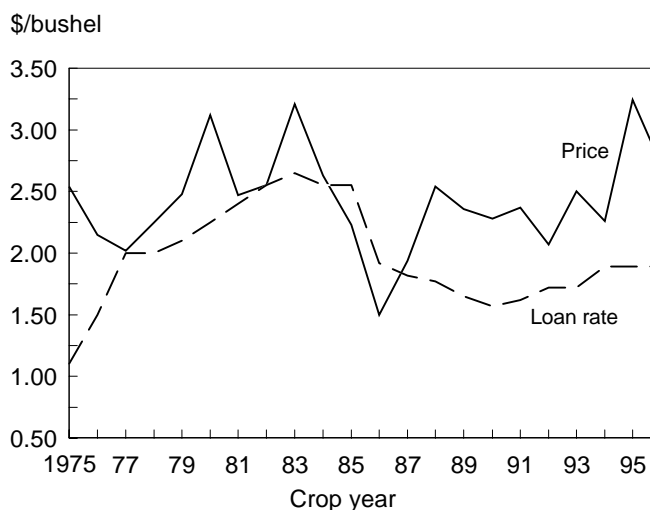
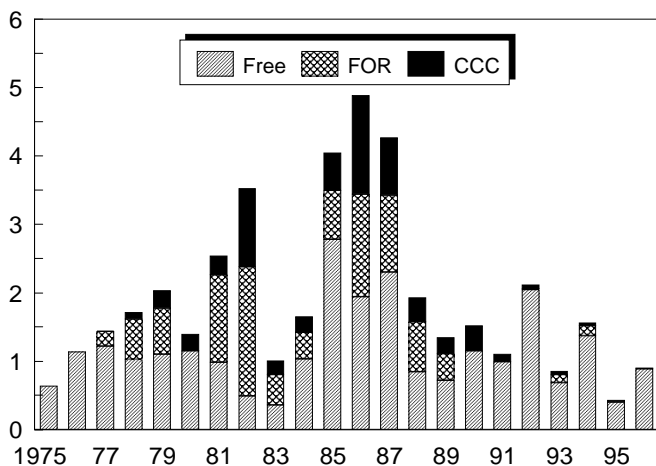


Figure E-2  
**Corn Stocks**

Bil. bushels



on market prices, starting in 1986. First, price support levels for grains were sharply reduced. The loan rate for corn was lowered from \$2.55 per bushel in 1985 to \$1.92 per bushel in 1986. Second, corn produced in 1986-1990 was not permitted to enter the FOR. And third, corn in the reserve was more accessible to the marketplace as a new policy instrument introduced under 1985 farm law, generic certificates, allowed early access to grain in the reserve before its contract expired.

These policy changes facilitated a reduction in corn stocks in the late 1980s that was accelerated in 1988 when a major drought in the Corn Belt region of the United States sharply lowered corn production. Corn stocks fell from over 4 billion bushels to 1.5 billion bushels at the end of the 1990/91 season. Government-owned and FOR stocks fell from nearly 3 billion bushels to under 400 million by the end of 1990/91. Importantly, the combination of lower price supports, no further FOR entry, and generic certificates allowing access to FOR stocks eliminated the strong policy effect on price determination for corn. Essentially, the loan program continued to provide producers a source of short-term liquidity, but it no longer supported corn prices.

Policy changes since 1990 have continued to keep the price supporting aspects of the loan program at a minimum. Since 1986, the corn loan rate has ranged from \$1.57 per bushel to \$1.92 per bushel, well below market prices for corn in most years. Implementation of marketing loans for corn starting in 1993, which allow repayment of loans at less than the original loan rate, further reduced the loan program's potential effect on market prices. Although the availability of generic certificates declined in the early 1990s, FOR stocks continued to be accessible to the marketplace as a new FOR release policy allowed farmers to repay their FOR loans and reacquire the loan collateral at any time rather than when prices reached specific FOR release levels. Later, the 1996

Farm Act suspended the FOR. As a consequence, since 1986, price determination for corn has largely been based on market supply and demand conditions without the influence of the Government price support program.

### The Model

The general framework used here relating prices to ending stocks derives from an equilibrium model. In its simplest form, without the Government price support program, supply, demand, and stocks are each a function of price, with the market-clearing, equilibrium condition of determining the price at which supply equals demand plus stocks (equations 1-4).

- |     |                 |                         |
|-----|-----------------|-------------------------|
| (1) | $S = f(p)$      | (Supply function)       |
| (2) | $D = g(p)$      | (Demand function)       |
| (3) | $K = h(p)$      | (Stocks function)       |
| (4) | $S - D - K = 0$ | (Equilibrium condition) |

S is supply, D is demand, K is ending stocks, and p is market price. Supply is positively related to price, while demand and stocks are negatively related to price.

In equilibrium, prices can be determined from the inverse of the supply, demand, or stocks function. Taking the inverse of the stocks function provides a price determination equation, with prices negatively related to stocks.

- |     |                 |   |
|-----|-----------------|---|
| (5) | $p = h^{-1}(K)$ | (Price equation; inverse stocks function) |
|-----|-----------------|---|

Introducing the Government price support loan program adds to the stocks function by incorporating the commodity loan rate to the function, as represented in equation 3a.

- |      |                 |  |
|------|-----------------|--|
| (3a) | $K' = h(p; LR)$ | (Stocks function with Government loan program) |
|------|-----------------|--|

K' is the revised stocks function and LR represents the commodity loan rate. The Government loan program provides an additional feature to stockholding behavior that depends on the loan rate incentive to use the loan program.

With this alternative stocks function, the inverse stocks function gives the following price determination equation.

- |      |                      |
|------|----------------------|
| (5a) | $p = h^{-1}(K'; LR)$ |
|------|----------------------|

Prices would be expected to be negatively related to stocks. Prices would be expected to be positively related to the loan rate, particularly in those years that loan rates were set high relative to market clearing price levels and the Farmer-Owned Reserve isolated stocks from the marketplace.

### Model Implementation

The functional form used to estimate equation 5a for annual corn prices is logarithmic. Semi-log and exponential func-

tional forms can alternatively be used and provide similar estimation results to those presented here.

$$(6) \quad \ln(p) = a + b \ln(K'/U) + c \ln(LR) * \text{Dum7985}$$

U represents annual corn utilization, Dum7985 represents a dummy variable equal to 1 in 1979-1985 and equal to 0 in other years, and a, b, and c are parameters to be estimated.

In equation 6, stocks (K') are measured relative to an indicator of the "scale of activity" in the corn sector, represented by the realized level of demand, actual utilization (U). This adjustment is needed because of growth in the corn sector over the last 20 years, so a particular level of stocks today represents a smaller portion of total use (or realized industry demand) than the same level of stocks in 1975. The result is a stocks-to-use variable commonly used in price models, providing a summary measure of market supply and demand conditions and an indicator of relative market tightness for the commodity. The expected sign of the stocks-to-use coefficient (b) is negative.

The interaction term of the loan rate (LR) times the dummy variable (Dum7985) represents the effects of the loan program on corn prices from the late 1970s through the mid-1980s. The loan rate variable used in the model includes the higher FOR loan rate available to corn producers in 1980-1982. The years 1979-1985 chosen for the interaction term were when the commodity loan program, in conjunction with the structure of the Farmer-Owned Reserve program, had a significant influence on price levels in the sector. Loan rates were relatively high in those years and the multi-year Farmer-Owned Reserve program, with high release prices, isolated those reserve stocks from the market. The price supporting aspects of the loan program in the late 1970s through the mid-1980s imply that the expected sign for the coefficient (c) for the loan rate interaction term is positive.

This specification contrasts with the approach frequently used in the past of defining the dependent variable as corn price minus loan rate. For many of those earlier models, the years 1979-1985, (when high loan rates and the structure of the FOR program affected price determination), were a larger part of the sample period used for model estimation. Here, those years represent only 7 of the 22 observations, so a separate policy shift variable seems more appropriate, with the dependent variable being the corn price.

The specification of the interaction term represents an intercept shift related to the loan rate rather than a slope shift related to the stocks-to-use variable. An alternative specification that also included a slope shift adjustment for 1979-1985 produced a coefficient estimate for the slope shift variable that was not statistically different from 0.

Farm-level prices used to estimate the model are season average prices collected by the U.S. Department of Agriculture's

National Agricultural Statistics Service and republished by the Economic Research Service elsewhere in this *Feed Situation and Outlook Yearbook* (April 1998). Stocks, utilization, and loan rate data also are from this *Feed Situation and Outlook Yearbook*. FOR loan rate data for 1980-1982 are from Lin, Glauber, Hoffman, Collins, and Evans.

## Model Results

The model was estimated using ordinary least squares regression, with annual data from 1975 through 1996. The estimated logarithmic regression equation is:

$$(7) \quad \ln(p) = 1.534 - 0.2418 \ln(K'/U) \\ (20.1) \quad (9.6) \\ + 0.2828 \ln(LR) * \text{Dum7985} \\ (7.8)$$

$$R^2 = 0.857$$

$$F\text{-value} = 56.829$$

$$\text{Standard error of the estimate} = 0.0687$$

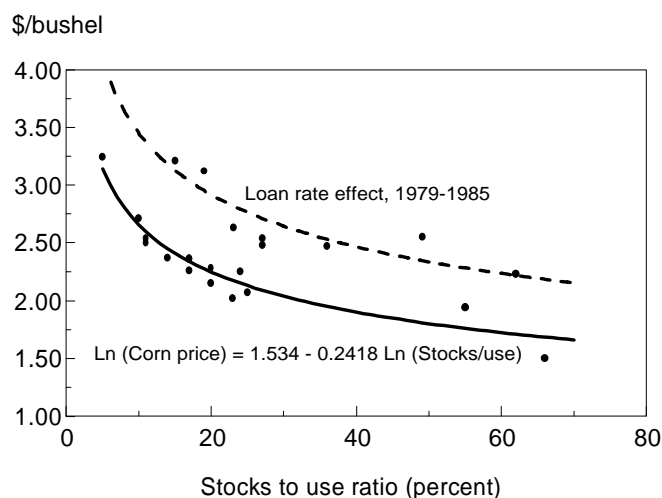
$$\text{Durbin-Watson statistic} = 1.921$$

Numbers shown in parentheses under each coefficient are t-statistics.

Over 85 percent of the variation in the logarithm of annual corn prices is explained by estimated equation 7. Transforming the equation to price levels, about 87 percent of the variation of annual corn prices is explained. Each coefficient has the expected sign, with a negative sign for the stocks-to-use variable and a positive sign for the loan rate shift variable. Each coefficient is significant at the 1 percent level.

A graph of the regression equation results is shown in figure E-3, adjusting from logarithms to levels of each variable. Corn prices are plotted against ending stocks-to-use ratios.

Figure E-3  
Corn Price Equation



The circles in figure E-3 represent the historical observations for the 1975-1996 estimation period. The lower price curve applies for all years except 1979-1985 and represents the equation that would currently be used for forecasting corn prices. The higher price curve represents the years 1979-1985, which incorporates the average price supporting effect of high loan rates in those years. The average difference between the two price curves for 1979-1985 is about 60 cents a bushel.

### Model Evaluation

Figure E-4 shows a graph of historical corn prices along with the predicted values derived from estimated equation 7. In general, the price model tracks actual corn prices well. Most differences between the model estimate and the actual corn price are less than 15 cents a bushel. The largest difference is in 1988, a year of a major drought in the Corn Belt region of the United States.

Table E-1 shows mean absolute errors and mean absolute percentage errors for the full estimation period, 1975-1996, and for a selected subsample of recent years covering 1990-1996. For the full sample, the mean absolute error is about 11 cents a bushel, with a mean absolute percentage error under 5 percent. Importantly, for price forecasting applica-

tions, model performance is better in recent years (the 1990s), with a mean absolute error of about 7 cents a bushel and a mean absolute percentage error of 2.8 percent. These statistical measures indicate good performance for the corn price model.

### Corn Price Forecasts

The USDA corn sector projections in April 1998, as published in the *World Agricultural Supply and Demand Estimates*, imply a 1997/98 ending stocks-to-use ratio of 13.4 percent. Using this stocks-to-use ratio, the corn price model's forecast for 1997/98 is \$2.48 per bushel. This price forecast is near the middle of USDA's April 1998 corn price projection range of \$2.45 to \$2.55 per bushel.

Table E-2 shows the estimated model's corn price forecasts for different stock-to-use ratios.

### Implications of U.S. Agricultural Policy Changes for Potential Annual Price Variability

Changes in commodity stocks policies and supply management programs since the mid-1980s have significantly changed U.S. agriculture from the highly managed sector of the early 1980s to a more market-oriented sector today. These policy changes have implications for potential inter-year, annual price variability.

Figure E-4

#### Corn Prices--Actual and Model Estimate

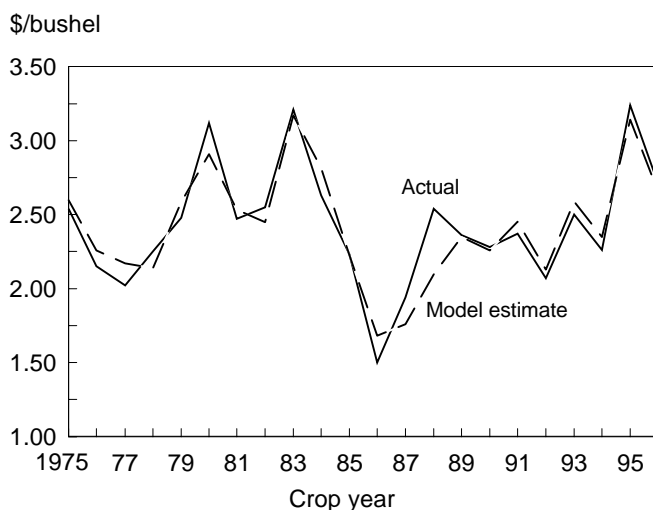


Table E-1--Model performance measures, selected periods

Time period	Mean	Mean absolute
	absolute error	percentage error
	Cents per bushel	Percent
1975-1996	11.1	4.8
1990-1996	7.1	2.8

Table E-2--Model estimates of annual corn prices for different stocks-to-use ratios

Stocks-to-use ratio	Corn price model forecast
Percent	Dollars per bushel
5	3.14
6	3.01
7	2.90
8	2.80
9	2.72
10	2.66
11	2.60
12	2.54
13	2.49
14	2.45
15	2.41
16	2.37
17	2.34
18	2.30
19	2.27
20	2.25
21	2.22
22	2.20
23	2.17
24	2.15
25	2.13

A corn sector model that includes the price equation presented in this article was used to compare price variability in different policy settings when the sector faces shocks. Short-run impacts of shocks on prices, when only demand and prices adjust, as well as longer run price impacts over a multi-year, post-shock period when supply also adjusts, were analyzed.

Under current policy, carryover stocks of corn and corresponding stocks-to-use ratios are lower than they typically have been over the last 30 years. Thus, price determination is in the steeper parts of the price function estimated in this article and shown in figure E-3. As a consequence, prices in the short run, when only demand and prices adjust, are more responsive to shocks than if stocks were larger and price determination occurred in a flatter portion of the pricing function.

In the longer run, supply also adjusts. Importantly, a higher supply response elasticity associated with policy shifts to full planting flexibility allows a larger response to market price movements. In combination, the interaction of increased supply responsiveness with initially greater short-run price impacts can accelerate adjustments to shocks and mitigate longer run, annual price volatility.

## Conclusions

The corn price model presented in this paper uses a stocks-to-use ratio formulation. The model also addresses issues regarding the historical influence of Government commodity loan and storage programs on corn price determination. Loan programs are shown to have had an effect on corn prices in the late 1970s through mid-1980s. However, with farm program changes under 1985 farm legislation, Government commodity loan and storage programs have not had as much influence on prices. Price determination is now based on market supply and demand factors without the influence of the Government price support program. The stocks-to-use ratio used in the model captures these market effects.

Statistical model evaluation measures as well as the graph of actual prices and model estimates indicate good performance for the corn price model. This is particularly the case given the large range of corn prices over the sample period used to estimate the model (1975-1996) as well as the changing nature of the influence of Government programs on corn price determination.

Changes in U.S. agricultural commodity policies over the last 10-15 years have implications for potential inter-year, annual price variability. With smaller carryover stocks of corn than typically held over the past 30 years, price determination is in the steeper parts of the price function, so

prices are initially more responsive to shocks. In the longer run, with full planting flexibility, greater supply responsiveness facing initially greater price impacts can accelerate corn sector adjustments to shocks and mitigate longer run, annual price variability.

The relatively simple structure of the estimated reduced form model for corn prices and the model's minimal data requirements lend themselves to easy use in corn price forecasting applications in conjunction with market analysis of supply and demand conditions. In particular, the model is used within USDA as part of the Department's short-term market analysis and long-term baseline projections activities.

## References

- Baker, Allen and Keith Menzie. "Drought Effects on Corn Price Forecasts," *Feed Situation and Outlook Report*, FdS-307, USDA-ERS, August 1988, pp. 25-28.
- Lin, William, Joseph Glauber, Linwood Hoffman, Keith Collins, and Sam Evans. *The Farmer-Owned Reserve Release Mechanism and State Grain Prices*. U.S. Department of Agriculture. Economic Research Service. ERS Staff Report AGES850717, August 1985.
- Lin, William, Peter Riley, and Sam Evans. *Feed Grains: Background for 1995 Farm Legislation*. AER-714, USDA-ERS, April 1995.
- U.S. Department of Agriculture. *Feed Situation and Outlook Yearbook*. Economic Research Service. FDS-1998, April 1998.
- U.S. Department of Agriculture. *Storage Subsidy Programs*. Economic Research Service. Staff Report AGES-9075, December 1990.
- U.S. Department of Agriculture. *World Agricultural Supply and Demand Estimates*. World Agricultural Outlook Board. WASDE-337, April 1998.
- Van Meir, Lawrence W. "Relationships Among Ending Stocks, Prices, and Loan Rates for Corn," *Feed Outlook and Situation Report*, FdS-290, USDA-ERS, August 1983, pp. 9-13.
- Westcott, Paul C., David B. Hull, and Robert C. Green. "Relationships between Quarterly Corn Prices and Stocks," *Agricultural Economics Research*, Vol. 37, No. 1, Winter 1985, pp. 1-7.
- Young, C. Edwin and Paul C. Westcott. *The 1996 U.S. Farm Act Increases Market Orientation*, Agricultural Information Bulletin 726, August 1996.